Hydraulic Actuator Using Novel Technology (HAUNT)

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DARPA Technical Interchange Meeting (TIM)/
Compact Hybrid Actuation Program (CHAP) Kickoff

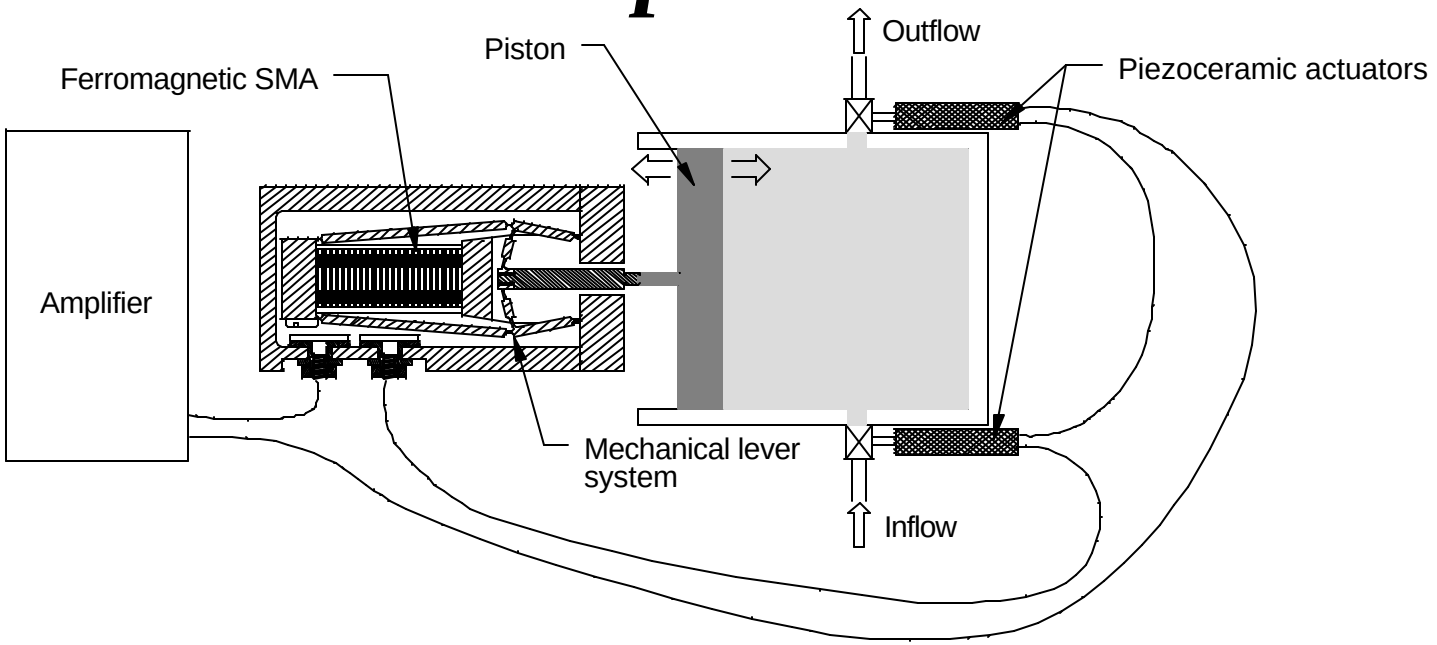
June 26-28, 2000
Baltimore, MD

Objective and Scope of the Phase I Program

The objective is a successful proof of concept for smaller and more efficient hydraulic actuation system by employing ferromagnetic shape memory alloy to drive the fluid pump and piezoelectric ceramic actuator to operate flow control valves.

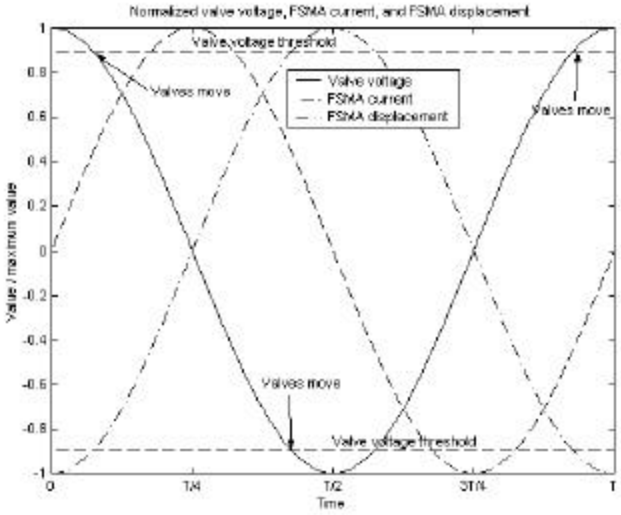
The scope of the Phase I program includes design of pump and electronics, fabrication, and testing as a bench top proof-of-concept model.

HAUNT Concept

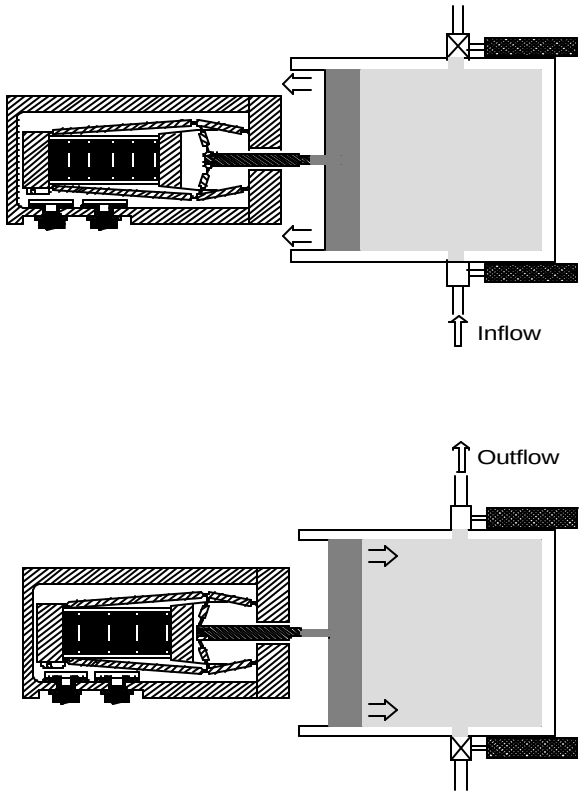


A ferromagnetic shape memory alloy drives a fluid piston through a mechanical levering system. Fluid flow is controlled using mechanically bistable valves operated by piezoceramic actuators. Piezoceramic and ferromagnetic actuators are connected in series and driven by a common amplifier. Energy flow is maximized by operating the system at the mechanical resonance of the pump and the electrical resonance of the ferromagnetic/piezoceramic system.

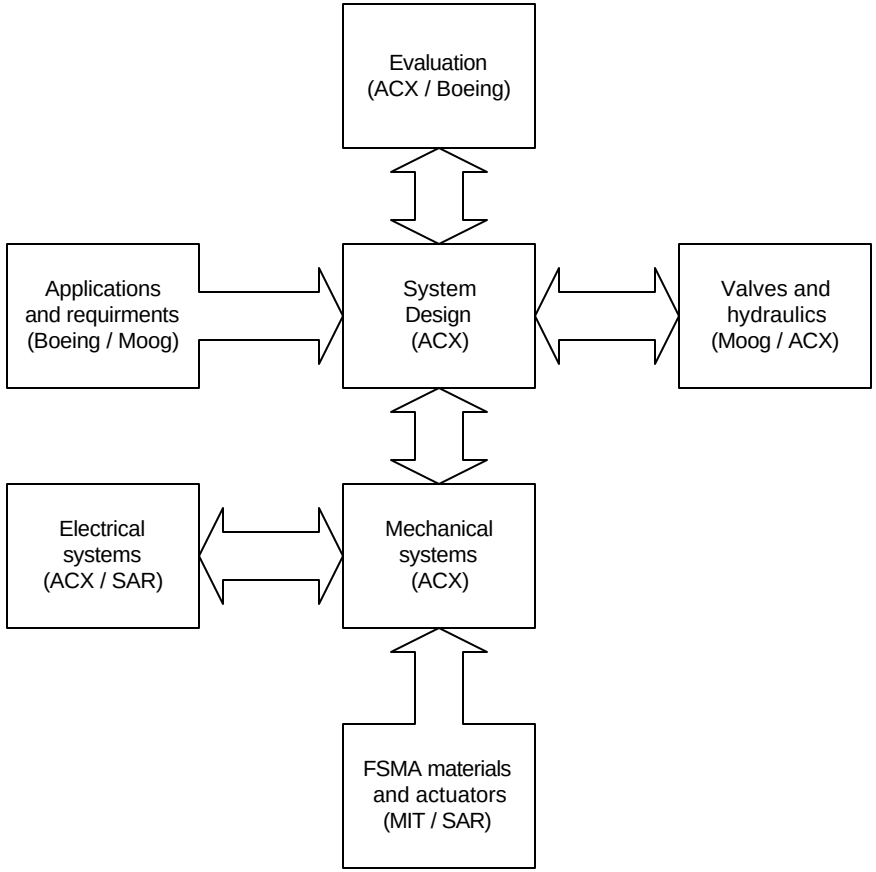
HAUNT Concept



Operating voltage and current of the system over a single period of oscillation



Team Members and their Role



HAUNT Team Members

Technical POC

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<Leading organization>					
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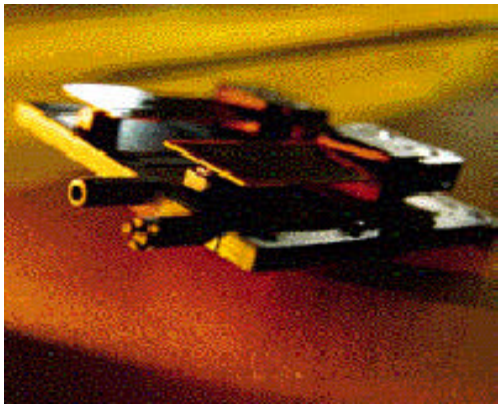
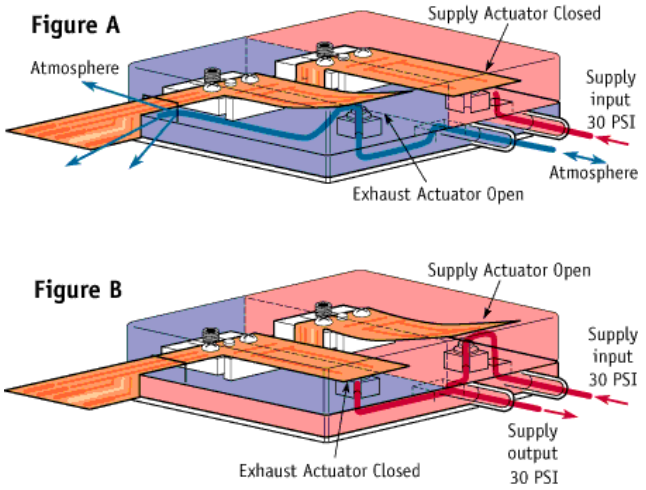
Moog: Moog Inc. Aircraft Group	Seneca & Jamison Rd. East Aurora, NY 14052
Boeing: The Boeing Company	P.O. Box 516 MC S102-1310, St Louis, MO 63166-0516

Piezoelectric Actuators

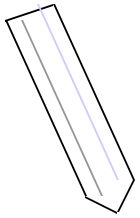




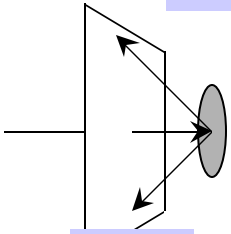
-An example of ACX QuickPack bimorph actuator designed for Landis&Stafa's Analog Output Valve controls a pnumatic air pressure.
-Haunt may require stack actuator.

Ni-Mn-Ga FSMAs

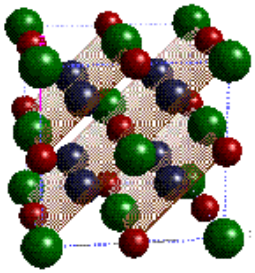
- **Crystal, chemistry**



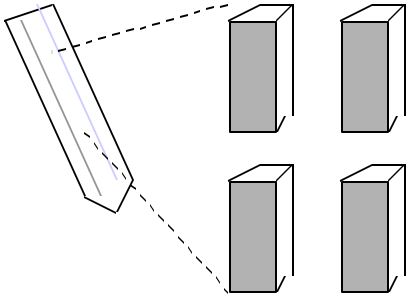
- **Orientation**



Laue

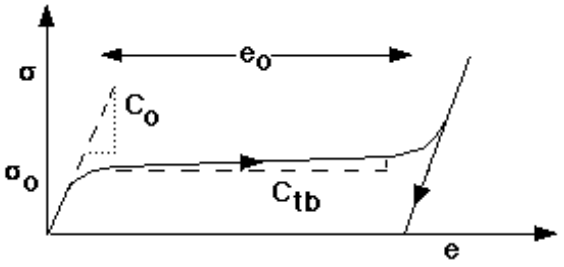


- **Cut actuators**

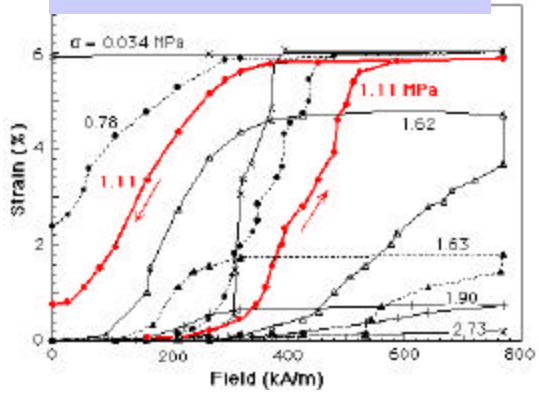


- **Heat treat**

- **Characterize stress v. strain**



- **Char. strain vs. *H*, *s***



- **Deliver actuators,**

  Iterate process

Ni-Mn-Ga FSMAs

Objectives

Supply Ferromagnetic Shape Memory Alloy samples . . .

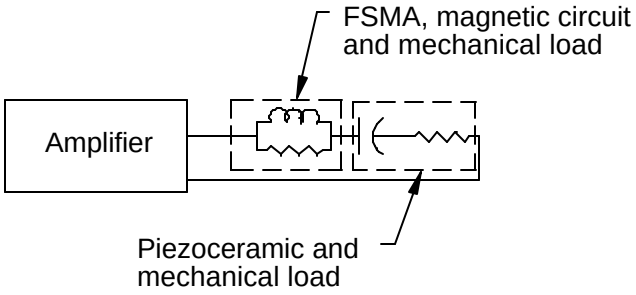
- **Purchase FSMA crystal** of specified composition
- **Verify composition** - electron probe microanalysis (EPMA)
- **Orient crystal** - Laue x-ray diffraction
- **Cut actuators** - electric discharge milling

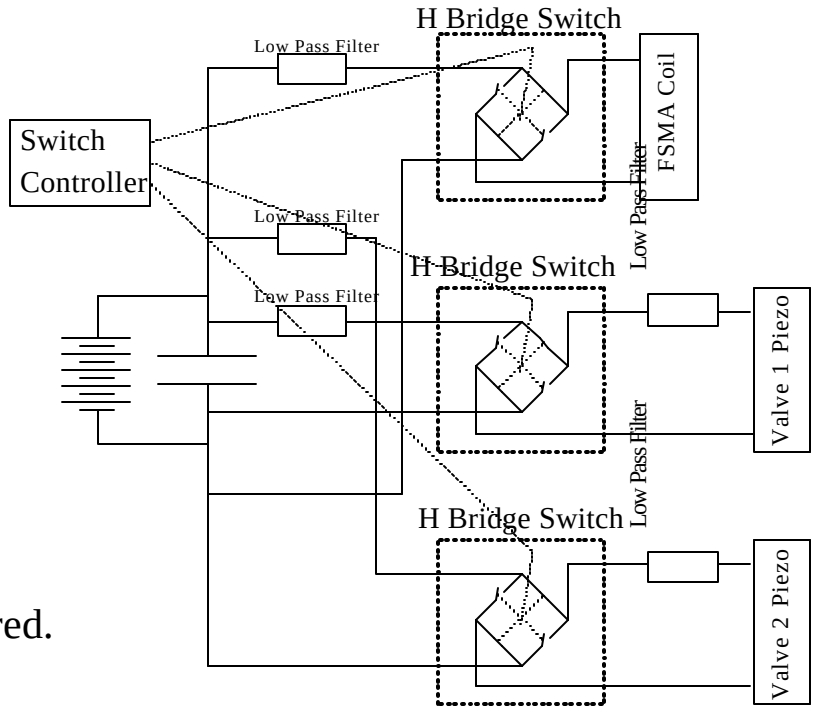
. . . Suitable for ACX hybrid actuator

- **Heat treat** - relieve stress, chemical ordering, avoid precipitation
- **Collaborate on design** - optimized actuator magnetics, bias
- **Characterize** $\varepsilon(s,H)$, $M(H,T)$
- **Deliver actuators to ACX**

. . . **Iterate** to optimize chemistry, anneal, response

Electronics Development





Electrical representation of Amplifier/FMSA/Piezoceramic circuit, and schematic of the power electronics. Potential use of energy recycling between FMSA and Piezoceramic is being considered.

Target Application

- **Moog Inc.**

The X-36 demonstrator air craft

Typical X-36 Actuator
(6.35 in. long pin to pin)

- **Boeing**

  Potential application toward UCAV

Technical Innovations and Challenges

•Actuator application of the new research materials (FSMA).

•Combination of the different smart materials, PZT and FSMA, with innovative electronics development to achieve desirable system properties.

•Development of low loss mechanical displacement amplification and small scale hydraulic system.

• Proof of concept to hardware deliverable possibility for desired application.

Schedule

WBS	Task Name	Q1	Q2	Q3	Q4	Q5	Q6	Q7
1	Target performance space & reporting							
2	System design and materials qualification							
3	Mechanical system design							
4	Electronics system design							
5	Hydraulic system design							
6	Actuator fabrication and test							
7	Mechanical fabrication and test							
8	Electronics fabrication and test							
9	Pump fabrication and test							
10	Prototype integration							
11	System testing and evaluation							